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The Sensitivity of Landing Gear Flexibility on Ground Manoeuvring Simulations

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Abstract

The present work has been carried out during a 12 months Internship in the Landing Gear Centre of Competence, Design Analysis Team (ELYD) within Airbus Operations Ltd at Filton, UK.

One of the main activities of ELYD is to provide results to Program ATA32 Integrators and Chief Engineers (ATA Chapter numbers provide a common referencing for all commercial aircraft documentation and ATA32 is the chapter regarding the Landing Gear) concerning aircraft performances during ground operations.

Currently rigid Landing Gear models are used to simulate dynamic ground manoeuvres using the software MSC ADAMS/View.

The aim of this thesis is to investigate how flexibility in Landing Gear can affect aircraft performances on ground operations.

Two different ways of representing flexibility have been considered during this work: Beam model and mnf model.

The comparison against the beam model has been done on the A350XWB. The comparison against the mnf model has been done on A320. This is due to model availability within Airbus.

Simulations show little differences in terms of turning performances. Flexible models give a more accurate load transfer to the airframe, however they require a much higher simulation time.

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Introduction

The landing gear is one of the basic aircraft systems, which plays a dominant role during ground manoeuvres. It is required to brake and steer the aircraft according to manoeuvrability requirements. The structure must support the aircraft weight and the landing and take-off loads the aircraft experiences. It must provide a safe, comfortable ride for the passengers or cargo on board.

The design of an aircraft landing gear also has difficult maintenance and fatigue requirements. It is one of the most exposed components when on ground and must be designed to withstand the operational environment of an aircraft runway.

The system must survive thousands of touchdowns over the aircraft lifecycle. Hence, it is critical that the system can be easily maintained and checked to ensure safety.

Simulation can be defined as the act of imitating some real life process or system, building and developing a model that reflects its real life behaviour using physics, mathematics and software tools. Modelling the aircraft landing gear allows validating the system design and ensuring that the system meets all technical requirements prior to being deployed on the real aircraft. These models help to ensure the landing gear can be integrated effectively into the final aircraft.

The Design Analysis team in the Landing Gear Centre of Competence (CoC) is responsible for the simulation and modelling of Landing Gear systems on many Airbus aircraft, currently including the A380 and the A350XWB.

It is a group of dynamic people that developed into a multi-disciplinary team which covers a wide range of subjects: it has world-class skills from the design of models to define and validate technical requirements, to the validation and verification of the Landing Gear system design, using a wide range of simulation techniques and analysis methods.

The Design Analysis team also delivers models to other Airbus teams to help support the integration of Landing Gear systems. The team is split in four main areas: Aircraft Systems, Avionics System, Physical Systems and Simulation and Modelling [1].

Currently rigid landing gear models are used to simulate dynamic ground manoeuvres using the software MSC ADAMS/View.

ADAMS is a family of interactive motion simulation software developed by Mechanical Dynamics and is owned by MSC Software. It is a motion simulation solution for analyzing the complex behaviour of mechanical assemblies. ADAMS allows the user to test virtual prototypes and optimize designs for performance, safety, and comfort, without having to build and test numerous physical prototypes.

Core packages of the ADAMS family are ADAMS/View, ADAMS/Solver, and ADAMS/PostProcessor. ADAMS/View is the graphical user interface of ADAMS, which gives the user the opportunity to build the models from scratch, or offers basic predesigned models in the library.

The ADAMS/Solver is provided in FORTRAN and in C-code and is the numerical analysis application of ADAMS. It solves the equations of motion for kinematic, static, quasi-static, and dynamic simulations.

ADAMS/PostProcessor supports the user in analysing the results of the simulation [2].

The modelling is an important part of the engineering process; a model which represents all system components in a very detailed way it is not necessarily the best model. A high detailed model results in high computational time and high complexity, which makes the analysis more costly. If the model is too simple, important information could be missed. It is necessary to identify the most important systems which have to be modelled, in order to capture the model requirements. The goal is to build a simple and fast model that fulfils analysis criteria.

The modelling process, illustrated in figure 0.1, starts with the identification of the model requirements and it is an iterative process. The purpose of this process is to build and test small elements or subsystems of the model before building the entire model. It starts by building sets of components with low level of detail. After the components are built they are tested to make sure that there is no error in the model. The following review gives the input for the improvements which were decided in the review. Once the model at this level is adequate, the process starts again with a higher level of detail.

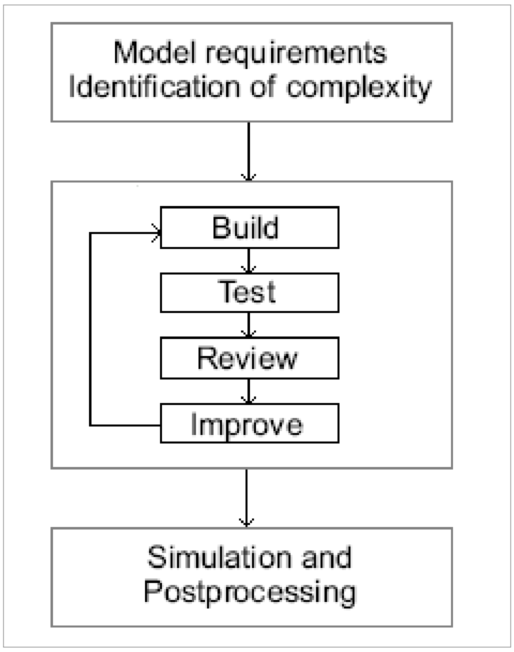

Figure 0.1 - Modelling process

The purpose of this thesis is to understand what are the benefits in taking flexibility into account and how complex is to set up the flexible model for ground manoeuvrability.

The flexibility has been taken into account initially with two different approaches, one based on a flexible beam model for the Airbus A350XWB-900 and the other one based on a flexible .mnf model of the Airbus A320.

A third approach comes from a results review, it is a model composed by a rigid main fitting and a flexible beam sliding tube.

The key parameters used to measure the added value of flexibility are:

1. Turning Radius
2. Turn Width

3. Tyre Side Forces
4. Torque between the main fitting and the strut
5. Computational time

In the first chapter there is an overview about the way flexibility effects have been evaluated, the simulated scenario and which comparisons have been done.

In the second chapter there is a brief description about the current rigid model and the assumptions done for building it.

The third and the fourth chapters describe the flexible beam model, and the flexible .mnf model, how to integrate flexible parts in the existing ground manoeuvrability models.

In the fifth chapter there is a description about the third approach, which comes out merging the two previous models.

Results are included in the chapter six followed by conclusion and possible further developments.

Theoretical background about multibody simulations, flexible beam theory and flexible bodies' background in ADAMS can be found in the appendixes.